

**Amendments to the Drawings:**

The drawing sheets attached in connection with the above-identified application containing Figures 6(a), 6(b), 8(a) - 8(d), 9(a) - 9(d), and 14(a) - 14(d) are being presented as replacement sheets to be substituted for the previously submitted drawing sheets containing Figures 6(a), 6(b), 8(a) - 8(d), 9(a) - 9(d), and 14(a) - 14(d).

The above figures are amended to better depict shaded portions thereof.

## **REMARKS**

### **Status of Claims:**

Claims 1-20 were pending at the time of the Office action. Claim 1 is amended. Claims 4-20 are cancelled without prejudice or disclaimer. New claims 21-25 are added. No new matter is added. Thus, claims 1-3 and 21-25 are now pending in the application. A detailed listing of all claims that are in the application, is presented, with appropriately defined status identifiers.

### **Objections to the Drawings**

In paragraph 5 of the Office Action, the drawings were objected to because Figures 6(a), 6(b), 8(a) - 8(d), 9(a) - 9(d), and 14(a) - 14(d) were deemed informal. Here, the Examiner stated: "Specifically, the shading used in the figures makes it difficult to discern the features. This problem will be exacerbated in future reproductions."

Accordingly, Applicants have submitted herewith replacement sheets that better depict the shaded portions of the above figures. As such, Applicants respectfully request that the objections to the drawings be withdrawn.

### **Objections to the Specification**

In paragraphs 6 and 7 of the Office Action, several objections to the specification were raised. Applicants have amended the corresponding portions of the specification, as requested by the Examiner. As such, Applicants respectfully request that the objections to the specification be withdrawn.

### **Objections to the Claims**

In paragraph 11 of the Office Action, claim 1 was objected to because of a minor clerical error. As amended herein, claim 1 recites "... a silicon molar ratio ( $\text{Si}/(\text{Si}+\text{Hf})$ ) in said metal oxide film . . ." As such, Applicants respectfully request that the objections to the claims be withdrawn.

**Rejections of Claims 1 and 3 Under 35 U.S.C. §§ 102 and 103**

In paragraph 12 of the Office Action, claims 1 and 3 were rejected under 35 U.S.C. 102(e) as being anticipated by Nishiyama et al. ("Nishiyama," U.S. Patent Application Publication No. 2003/0218223) or, alternatively, under 35 U.S.C. 103(a) as being unpatentable over Nishiyama in view of Visokay et al. ("Visokay," U.S. Patent Application Publication No. 2003/0045080).

The rejections of claims 1 and 3 are respectfully traversed.

As amended, claim 1 recites a semiconductor device comprising a MIS-type field-effect-transistor (FET), said MIS-type FET including:

a silicon substrate;

an insulating film formed on said silicon substrate and containing silicon and at least one of nitrogen and oxygen;

a metal oxide film formed on said insulating film and containing silicon and hafnium; and

a gate electrode formed on said metal oxide film, wherein:

**a silicon molar ratio ( $\text{Si}/(\text{Si}+\text{Hf})$ ) in said metal oxide film is not lower than 2% and not higher than 15%; and**

**said metal oxide film has a dielectric constant in a range from about 20 to about 24.** (Emphasis Added).

Applicants respectfully submit that neither Nishiyama nor Nishiyama in view of Visokay discloses or suggests all of the features of claim 1.

**Rejections Under 35 U.S.C. § 102**

In paragraph 14 of the Office Action, the Examiner states: "The limitation regarding the silicon molar ratio is inherently disclosed since Nishiyama teaches that the metal oxide film (12) can be  $\text{HfSiOx}$ ."

Applicants respectfully disagree that the noted feature (i.e., **a silicon molar ratio (Si/(Si+Hf)) in said metal oxide film is not lower than 2% and not higher than 15%**) is inherently disclosed in Nishiyama. Further, Applicants respectfully submit that Nishiyama does not disclose or suggest “**said metal oxide film has a dielectric constant in a range from about 20 to about 24**”, as also recited in claim 1.

Nishiyama discloses that “the gate insulating film 12 is formed of high dielectric material[.]” (Paragraph [0081]). Although Nishiyama discloses that “compounds (silicates) of these metal oxides and silicon, such as HfSiO<sub>x</sub> and ZrSiO<sub>x</sub>, can also be mentioned” (Paragraph [0081]), the Examiner apparently acknowledges that Nishiyama does **not** expressly disclose **a silicon molar ratio (Si/(Si+Hf)) in said metal oxide film is not lower than 2% and not higher than 15%**.

In contrast, Nishiyama does expressly disclose that “the gate insulating film 12 is formed of high dielectric material having a dielectric constant higher than a silicon oxide.” (Paragraph [0081]). Nishiyama also discloses that “the relative dielectric constant of SiO<sub>2</sub> is as low as about 3.9.” (Paragraph [0006]) (Emphasis Added).

As provided in page 4, lines 12-23 of Applicants’ specification:

As one of the materials satisfying the above requirements, a mixed-oxides material including silicon oxide and an oxide of a metal other than silicon is investigated. For example, Ti-Si-O, Zr-Si-O, Hf-Si-O and La-Si-O are enumerated as typical examples of such materials. These materials are stable at higher temperatures of 1000 degrees C or above.

However, there is a problem in that those materials have an extremely reduced dielectric constant due to inclusion of silicon. For example, Hf-Si-O having a metal composition ratio of 1:1 has a dielectric constant of 10-15. (Emphasis Added).

As described above in Applicants’ specification, Hf-Si-O, having a metal composition ratio of 1:1, has a dielectric constant of 10-15. A dielectric constant of such a material (10-15, as disclosed in Applicants’ specification) is higher than that of silicon oxide (about 3.9, as disclosed in Nishiyama). Therefore, such a material (i.e., Hf-Si-O, having a metal composition ratio of 1:1) could form the gate insulating film 12 of Nishiyama.

Such a material, however, does not have “a silicon molar ratio (Si/(Si+Hf)) in said metal oxide film [that] is not lower than 2% and not higher than 15%[.]” Further, such a material does **not** have a dielectric constant in a range from about 20 to about 24.

In contrast, Applicants’ specification describes, with reference to certain embodiments, that a metal oxide containing hafnium and silicon in a specific composition range has certain properties. For example, among other features, Applicants’ Fig. 2 provides a graph showing the relationship between the dielectric constant and the silicon molar ratio. Page 11, lines 11-23 of Applicants’ specification provides:

As described heretofore, the principal feature of the present embodiment is that a metal oxide containing hafnium and silicon in a specific composition range is used as a material configuring the gate insulating film of a MISFET. In the heat resistance property, i.e., the gate leakage characteristic after the activating anneal for source/drain, an advantageous difference was observed at a silicon molar ratio (Si/(si+Hf)) of 2% or above in the metal oxide film, and above this silicon molar ratio, there was little influence by the silicon concentration. On the other hand, the dielectric constant scarcely changed until the silicon molar ratio in the metal oxide film reached 15%, and reduced significantly after exceeding the 15%. FIG. 2 shows this relationship. (Emphasis Added).

At least for the reasons explained, Applicants respectfully submit that the gate insulating film 12 of Nishiyama (for which HfSiOx is mentioned) **does not necessarily or inherently possess** features of the embodiment claimed in claim 1. Therefore, it is believed that claim 1 is not anticipated by Nishiyama.

At least because claim 3 depends from 1, it is believed that claim 3 is not anticipated by Nishiyama.

#### Rejections Under 35 U.S.C. § 103

In paragraph 17 of the Office Action, the Examiner states: “Visokay teaches the use of the material  $\text{Hf}_x\text{Si}_{1-x}\text{O}_2$ , where  $0 \leq x < 1$  as a metal oxide gate dielectric [0012].” In paragraph 17, the Examiner further states: “This material satisfies the limitation of a silicon molar ration [sic] (Si/(Si+Hf)) in the metal oxide film between 2% and 15%.”

Applicants respectfully disagree that Visokay discloses or suggests “**a silicon molar ratio (Si/(Si+Hf)) in said metal oxide film is not lower than 2% and not higher than 15%**”, as recited in claim 1. Rather, with respect to specific examples, Visokay describes materials that appear to fall outside the recited range. Further, Applicants respectfully submit that Visokay does not disclose or suggest “**said metal oxide film has a dielectric constant in a range from about 20 to about 24**”, as also recited in claim 1.

With respect to specific examples, Visokay discloses a composition having a silicon molar ratio that is **substantially higher than 15%**.

For example, Visokay discloses a dielectric of “roughly  $\text{Hf}_{13.4}\text{Si}_{22.2}\text{O}_{33.1}\text{N}_{31.3}$ [.]” (Paragraph [0020]; see also paragraph [0024]). Visokay also discloses that “the dielectric film does not necessarily need to contain nitrogen to benefit from the current invention.” (Paragraph [0020]). Therefore, it appears that such a dielectric satisfies the conditions described in Visokay, as cited by the Examiner (i.e.,  $\text{Hf}_x\text{Si}_{1-x}\text{O}_2$ , where  $0 \leq x < 1$ ). **However**, such a dielectric does not have **a silicon molar ratio (Si/(Si+Hf)) in said metal oxide film is not lower than 2% and not higher than 15%**. In contrast, the dielectric of Visokay (i.e.,  $\text{Hf}_{13.4}\text{Si}_{22.2}\text{O}_{33.1}\text{N}_{31.3}$ ) would appear to have a silicon molar ratio **substantially higher than 15%**. Similarly, the dielectric disclosed by Visokay in Paragraph [0024] (i.e.,  $\text{Hf}_{14.2}\text{Si}_{20.3}\text{O}_{40.9}\text{N}_{24.6}$ ) appears to satisfy the conditions  $\text{Hf}_x\text{Si}_{1-x}\text{O}_2$ , where  $0 \leq x < 1$ , but also has a silicon molar ratio **substantially higher than 15%**.

Furthermore, the dielectric of Visokay does **not** have **a dielectric constant in a range from about 20 to about 24**. Rather, Visokay discloses that the “deposition of this metal silicon oxynitride results in an effective dielectric constant of about 14[.]” (Paragraph [0020]) (Emphasis Added).

At least for the reasons explained, Visokay does not disclose or suggest features of claim 1 that were explained to be missing from Nishiyama. Therefore, it is believed that claim 1 is patentable over Nishiyama in view of Visokay.

At least because claim 3 depends from 1, it is believed that claim 3 is patentable over Nishiyama in view of Visokay.

**Rejection of Claim 2 Under 35 U.S.C. § 103**

In paragraph 20 of the Office Action, claim 2 was rejected under 35 U.S.C. 103(a) as being unpatentable over Nishiyama in view of Kinoshita et al. (“Kinoshita,” U.S. Patent No. 6,780,708).

The rejection of claim 2 is respectfully traversed.

Claim 2 depends from claim 1. Claim 2 further recites: “wherein said metal oxide film includes therein polycrystalline particles **having diameters of not smaller than 30nm and smaller than 100nm.**” (Emphasis Added).

The cited portion of Kinoshita discloses “the aforementioned materials in porous, amorphous, single crystal, polycrystalline, or nanocrystalline form[.]” (Col. 9, lines 8-10). However, Applicants are unable to find in Kinoshita disclosure or suggestion of polycrystalline particles having diameters of **not smaller than 30nm and smaller than 100nm.**

Furthermore, as previously noted, claim 2 depends from claim 1. Applicants are unable to find in Kinoshita disclosure or suggestion of features of claim 1 that were explained to be missing from Nishiyama and/or Visokay.

At least for the reasons explained, it is believed that claim 2 is patentable over Nishiyama in view of Kinoshita.

**New Claims**

Newly added claims 21-25 depend, either directly or indirectly, from claim 1. At least for this reason, it is believed that claims 21-25 are patentable over the cited references. Further, it is believed that claims 21-25 recite features that are neither disclosed nor suggested by the cited references.

**Concluding Remarks**

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by the credit card payment instructions in EFS-Web being incorrect or absent, resulting in a rejected or incorrect credit card transaction, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicants hereby petition for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Respectfully submitted,

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